Spectrum skeletonization: a new method for acoustic sign feature extraction

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Nowadays, the noisy acoustic signals investigating by machine learning algorithms is a frequently researched topic in the signal processing. They play an important role in speech recognition algorithms and industrial applications as well. To find the appropriate parameters is a keypoint of the learning process of machine learning. The parameter sets are optimal if they produce different results for objects having different quality and similar results for those ones that are similar in quality. Methods, that are used in practice, search a threshold hit in the given time series or provide some parameters extracted from the auto power spectrum density (APSD) function (e.g., the Root Mean Square Rate calculation). In present work we propose a novel method to analyze the APSD function. The benefits of the skeletonization can be useful to determine relevant frequency components in the APSD function [1].

Skeleton is a shape descriptor which summarizes the general form of objects [2]. Although the power spectrum is a vector of density values corresponding to different frequencies, we can map it into a binary image. Centerlines provide structural and geometric information about the APSD function. The relevant peaks in it are represented by skeletal branches. Removing the "main branch" of the skeleton (i.e., the lower curve segments that ensure the connectivity between the vertical side branches), we split it into disjunct trees. The frequency having the minimal density value between the skeletal trees is the proper location to separate the frequency ranges. By this way no peak are split unlike in the former methods. In Fig. 1, the vertical dark gray lines indicate the bounds of the frequency ranges, and the skeletal trees are also superimposed with black curves in the picture. Usually the skeletal trees are inside in their frequency ranges, however in some cases the lower branch of a skeletal tree may grow into the neighbour range. In order to separate the frequency ranges we have to consider the upper side branches of a skeletal tree (i.e., that represents a peak of the APSD). Furthermore, the geometry of skeletal branches in frequency range holds useful information that can be used for shape analysis.

According to our best of knowledge, there is no other acoustic verification system that uses skeletons to analyze the structure of the APSD function of a vibration sample.

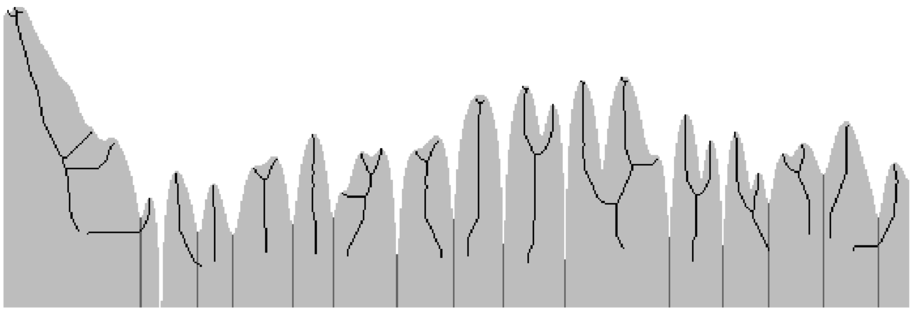

Figure 1: The APSD function of a vibration sample. Its skeletal branches are superimposed with black curves, while the frequency component bounds are indicated by dark gray vertical lines.

References

[1] T. Dobján, Sz. Pletl, T. Deák, L. Doszpod, and G. Pór: Identification of the place and materials of knocking objects in flow induced vibration, Acta Cybernetica 20 (2011) pp. 53-67.

[2] K. Siddiqi, S.M. Pizer (Eds.), Medial Representations – Mathematics, Algorithms, and Applications, Series in Computational Imaging, Springer, 2008.